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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAM

OF THE

LOS ANGELES MEETING

AT

THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES

CALIFORNIA

DECEMBER 21–22, 1934

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LOS ANGELES MEETING

THE 195th regular meeting of the American Physical Society will be held in the auditorium of the Physics Department at the University of California at Los Angeles, Los Angeles, California, on Friday, December 21, and Saturday, December 22, 1934. The morning session of the Physical Society will begin at 9 o'clock on Friday and the afternoon session at 1:30 o'clock on the same day. The session on Saturday morning will begin at 9 o'clock, and will be resumed at 2 o'clock if the number of papers on the supplementary program warrants it. Saturday afternoon, unless spent in session, will be open for tours of inspection of the physics laboratory at the University of California at Los Angeles, and it is possible that a tour can be arranged through the sound laboratories of the motion picture industry if circumstances warrant it and enough members of the Society desire it.

Luncheon. Luncheons will be served at the Union in Kerckhoff Hall on the campus, following the morning sessions on Friday and Saturday. There will be a Society dinner Friday evening at El Encanto in Westwood Village, at the probable cost of a dollar a plate.

Hotels and Auto Camps. *Hotel Christie*, 6724 Hollywood Boulevard, rooms with bath, $2.50 and up; without bath $1.50 and up.

Hotel Clark, 426 South Hill Street, with bath $2.00 and up.

Hollywood Plaza Hotel, 1637 North Vine Street, single with bath, $2.50 and up; double with bath, $3.00 and up.

Pacific Palisades Auto Camp, Roosevelt Highway above Santa Monica.

Lincoln Auto Court, Santa Monica, Lincoln Boulevard and Marine Street, cottages $1.25.

The Brockton Cottages, Santa Monica, 1225 Brockton Avenue, cottages from $1.50 to $3.50.

Additional information will be available at the registration desk in the office of the Physics Department on request.

All members of the Society are requested to *register in the office of the Physics Department on arrival*, and to signify their intention of attending the luncheon and dinner, as well as to call for possible mail or messages.

Titles and abstracts of papers to be presented at the sessions will be given in the following pages. These abstracts have not been corrected by the authors. After correction they will be published in an early number of the Physical Review. Authors should send all corrections to the Editorial Secretary, American Institute of Physics, Inc., 11 East 38th Street, New York, N. Y.

Other meetings for the current season are as follows:

196. Pittsburgh. December 27–29, 1934. Annual Meeting.
197. February, 1935. New York City.
198. April, 1935. Washington, D. C.

LEONARD B. LOEB,
Local Secretary for the Pacific Coast,
University of California,
Berkeley, California.

December 5, 1934.

PROGRAM

FRIDAY MORNING AT 9:00 O'CLOCK

1. Chemical Identification of the Radioactive Element Produced from Carbon by Deuton Bombardment. L. N. RIDENOUR, D. M. YOST AND K. SHINOHARA, *California Institute of Technology.*—Because of the difference of half-lives of the radioactive elements produced by bombarding boron with alpha-particles (14 min.) and carbon with deutons (10.5 min.), which difference exists in spite of the fact that the products are presumably the same, a chemical investigation was undertaken to determine the nature of the radio-element produced in the latter case. Curie-Joliot and Joliot have given evidence that in the former case N^{13} results; the outcome of the present experiment indicates that the active element produced by bombarding carbon with deutons is also an isotope of nitrogen.

2. Gamma-Rays from Boron Bombarded with Deutons. H. R. CRANE, L. A. DELSASSO, W. A. FOWLER AND C. C. LAURITSEN, *California Institute of Technology.*—The energy spectrum of recoil electrons produced by the gamma-rays from boron bombarded with deutons has been studied by means of a Wilson cloud chamber operating in a magnetic field of 1000 gauss. The gamma-radiation was found to consist of components of at least five different energies, and these are in good agreement with the differences in energy of the proton groups, and with the known excitation levels in some of the nuclei which result from the transmutation.

3. The Disintegration of Nitrogen by Neutrons. FRANZ N. D. KURIE (*National Research Fellow*), *University of California.*—Measurements made on 29 Wilson cloud chamber photographs of the disintegration of nitrogen by neutrons are presented and discussed. It is shown that the loss in kinetic energy can be satisfactorily accounted for by postulating the momentary production of a radioactive nitrogen (N^{15}) by a radiative capture of the neutron. This nitrogen disintegrates with the emission of α-particles so that the half-life is on the Gamow theory around 10^{-20} sec. A distinction is thus made between nuclear transformations in which the energy absorbed is a constant (such as in the case of the disintegration of nitrogen by α-particles) and those in which the proper disintegration energy E is a constant. Disintegrations caused by neutrons are, as far as the data from cloud chamber measurements go, all of this latter type. For nitrogen E is found to be 3.1 mv. The scatter of the values of E is probably all due to be attributed to experimental error but may in part be due to the short life of the radioactive N^{15}. The energy level from which the α-particle leaves the N^{15} nucleus is roughly identified with the resonance level through which an α-particle may enter a B^{11} nucleus in the reverse reaction. A mass for the radioactive N^{15} of 15.0166 is proposed on the basis of the mechanism here discussed. The data of other workers on the transmutation of oxygen, fluorine and neon are reviewed in the light of these considerations and lend support to them. The values found for E are nearly the same for all of the four elements for which data exist.

4. The Energy of the Neutrons Emitted from Beryllium when Bombarded by Deutons. J. R. RICHARDSON AND FRANZ N. D. KURIE (*National Research Fellow*), *University of California.*—The energy of the neutrons emitted from beryllium when bombarded by deutons was studied by measuring the ranges and angles of projection of helium recoil atoms in a cloud chamber placed nearby. It was found, in a separate series of experiments, that 90 percent of the neutrons arrive at the chamber without having been scattered. Hence one can take the line drawn from the source to the point from which the recoil atom begins its flight as the neutrons path. The beginning and end of the helium recoil track not being distinguishable in general, the beginning was taken as that end which gives the minimum angle of projection. The final spectrum was corrected for the effect of the solid angle subtended by the chamber. One finds then a spectrum extending from below 1 mv through a maximum around 2 mv on up to 10 mv and perhaps beyond. It is difficult to set the upper limit of the energies because of the influence of the scattered neutrons. The decline in numbers between 2 mv neutrons and 10 mv neutrons is gradual. The maximum at 2 mv is perhaps not real since it was difficult to measure tracks of lengths smaller than those corresponding to about a 1 mv neutron.

5. Energy of the Neutrons from the Disintegration of Beryllium by Deutons. T. W. BONNER (*National Research Fellow*) AND W. M. BRUBAKER, *California Institute of Technology.*—Beryllium has been disintegrated by 900,000 e.v. deutons with the Lauritsen and Crane apparatus. The energies of the neutrons produced in this disintegration have been determined from the range of recoil protons observed in a Wilson cloud chamber which was filled with CH_4 at about 14 atmospheres pressure. The maximum of the proton ranges was found to be 28 cm which correspond to neutrons of maximium energy 4.5 m.e.v.

6. Transmutations of Aluminum by Deutons. EDWIN MCMILLAN AND ERNEST O. LAWRENCE, *University of California.*—Aluminum bombarded by 2.2 mv deutons is found to emit neutrons, protons, and alpha-particles, presumably accompanying the formation of Si^{28}, Al^{28} (radio aluminum), and Mg^{25}, respectively. The alpha-particles are very few in number and have a range of about 6.5 cm. The protons have a very complex spectrum of energies. By using a target of thin Al foil and a Wynne-Williams counter biased sufficiently to resolve groups 4 cm apart, it was possible to identify strong proton groups at 10 and 22 cm, weaker ones at 30 and 54 cm, and still weaker unresolved groups between the latter two and extending out to the maximum range of 62 cm. The radioactive product, shown chemically to be an aluminum isotope, emits negative electrons and a strong gamma-ray with a half life of 153

sec. The maximum range of the electrons is about 0.95 g/cm² of Al. The excitation curve of the radioactivity follows the Gamow nuclear penetration function very closely.

7. Transmutations of Nitrogen by Deutons. ERNEST O. LAWRENCE, EDWIN MCMILLAN AND MALCOLM C. HENDERSON, *University of California.*—Nitrogen bombarded by 1.3 mv deutons emits neutrons, protons and alpha-particles. The neutrons are involved probably in the reaction in which radio-oxygen (O^{15}) is formed. The protons and alpha-particles are probably emitted in the formation of N^{15} and C^{12}, respectively. There are two proton groups of ranges 25 and 85 cm, indicating a mass of 15.0049 for N^{15} and the frequent emission of a 4.6 mv γ-ray from N^{15}. There are three alpha-particle groups of ranges 6.7, 7.6 and 12.5 cm. The energy of the long range group agrees with that calculated from the mass spectrographic values for C^{12} and N^{14}, and the two shorter range groups suggest the existence of excited levels in C^{12} at 4.0 and 4.8 mv.

8. Photoelectric Effect and Spark Mechanism. A. M. CRAVATH, *University of California.*—To start a spark some additional mechanism is required in addition to the well known ionization by electron collision. Several mechanisms have been discussed but heretofore none has been shown to actually occur to the necessary extent under ordinary static breakdown conditions. The photoelectric effects produced by the radiation from electron currents in air at atmospheric pressure are being measured at low current densities and at fields in the breakdown range. There are at least two components of radiation. The first has an absorption coefficient in air of about 2 cm^{-1} and would release a photoelectric current 10^{-5} times (in order of magnitude) the current produced by electron collision if all the radiation struck brass. The second component has an absorption coefficient in air of about 10 cm^{-1} and is more effective in ionizing air than in releasing photoelectrons from brass. In order of magnitude, one such photo-ion is produced for every 10^4 ions produced by collision when all the radiation is absorbed in air. Fluorite stops both components. Hence they fall in the oxygen transmission region centering around 1100A. Intensities and absorption coefficients are of the right order of magnitude to explain the sparking potential for parallel electrodes in air at one atmosphere for gaps from 0.01 to 10 cm.

9. An Investigation of the Magneto-optic Method of Chemical Analysis. H. G. MACPHERSON, *University of California.*—An apparatus similar to that used by Allison in his magneto-optic method of chemical analysis was set up in an effort to verify the existence of the sharp Allison minima. Many visual observations were made, but only occasionally did readings of possible minima occur in more than random groupings. Where these apparent minima did occur, it was thought that they could be explained as being due to such factors as sticky places on the trolley felt by the hand on the hand wheel control. When a motor control was used on a later apparatus, the distribution of readings of possible minima was no more than a chance distribution. Objective tests were made of the variation of intensity of light with trolley position by a photographic method. In this photographic method the effect of spark fluctuations was eliminated by comparing the intensity of the light passing through the cells with that of a comparison beam direct from the spark. Individual runs by this method showed no minima and were good to 3 percent. When several runs were averaged, the resultant intensity curve showed no variations greater than 1 percent. Eye tests showed that the writer could not have detected an intensity change visually of less than 3 percent on the magneto-optic apparatus. Thus these results definitely indicate that the minima supposedly characteristic of chemical substances at times seen by the writer have no objective reality and hence no real significance.

10. Ionization of Inert Gases by Positive Alkali Ions with a Balanced Space-Charge Method. ROBERT N. VARNEY, *University of California.*—The study of ionization of inert gases by collisions of alkali ions reported last summer has been extended to include krypton, xenon, helium and methane. The method of detecting the newly formed ions is designed to be entirely unaffected by secondary electrons liberated from the walls. The ionization is allowed to take place in a cylinder which is already carrying a space-charge limited current of electrons. The positive ions formed tend to neutralize the space-charge, by the process discovered by Kingdon, in such a manner that an additional surge of about 50,000 electrons flows for each positive ion produced in the region. A second cylinder, identical with the first and carrying also a space-charge limited current of electrons but closed to the positive ions, is used to balance out spurious fluctuations in the electron current. The recent results indicate the following ionization potentials for the various alkali ions used as ionizers:

	Kr	Xe
K^+	72	115 volts
Rb^+	103	151

No ionization was observed below 500 volts either in methane or in helium. The possible similarity in electron configuration of argon and methane led to the study of the latter, but the intense ionization of argon was not duplicated.

11. Elastic Scattering of Fast Electrons in Mercury and Agreement with Mott's Theory. W. E. STEPHENS, *Washington University of St. Louis.*—Jordan has recently reported good agreement between Mott's theory and the experimentally measured angular distribution of elastically scattered electrons for 2000 volts in mercury in the angle range 0° to 42°. In view of Morse's criterion, that the minimum energy for which Mott's equations are accurate is of the order of $50Z^2$ (Z is the atomic number), we should not expect good agreement much below 320,000 volts in mercury. In preliminary experiments, with an apparatus developed to record the angular distribution of scattered electrons photographically, we have found a distinct maximum near 112° at 2000 volts in mercury. Since Mott's theory gives a monotone curve, we can conclude that there is not good agreement over the whole angular range for 2000 volts in mercury. In the apparatus used, a beam of fast electrons was shot through a molecular beam of

mercury. A retarding potential was used to stop the inelastically scattered electrons and an accelerating potential served to increase the blackening effect of the elastically scattered electrons at the film.

12. An Automatic High Pressure Wilson Cloud Chamber. W. M. BRUBAKER AND T. W. BONNER (*National Research Fellow*), *California Institute of Technology.*—A high pressure Wilson Cloud Chamber of new design has been built for the study of recoil protons from neutrons. The apparatus is entirely automatic in operation. It can be used at any pressure under 20 atmospheres. Illumination for photographing the proton tracks is obtained from a 2000-watt photo-flood lamp.

FRIDAY AFTERNOON AT 1:30 O'CLOCK

13. Polarization Effects in the Hilger E1 Quartz Spectrograph. JOSEPH W. ELLIS AND JOSEPH KAPLAN, *University of California at Los Angeles.*—Serious limitations are encountered in the use of the Hilger E1 spectrograph whenever the light is polarized or partly polarized. If the light is plane polarized in any plane except the vertical or horizontal the visible spectrum shows closely spaced striations whose visibility and number reach maxima when the plane of polarization makes a 45° angle to the vertical. At this angle there occur four positions of zero visibility. These striations are produced in the following way. The small crystalline quartz reflecting prism near the slit acts as a 300*th*-to-500*th* wave-plate. The quartz collimating lens rotates the planes of polarization to such angles that the waves acted upon in half-wave plate fashion and whole-wave plate fashion are parallel to or at right angles to the plane of incidence of the dispersing prism. Maxima and minima of intensity result and these interchange as positions of zero visibility are passed corresponding to polarizations at 45° angles to the plane of incidence. If the original light is polarized in a vertical or a horizontal plane, then the reflecting prism has no wave plate action, no striations appear and broad minima and maxima of intensity occur with the spacings of the former visibility minima.

14. New Band Systems in Nitrogen. JOSEPH KAPLAN, *University of California at Los Angeles.*—Spectra, taken on a Hilger E31 quartz spectrograph at pressures varying continuously from about 10 mm to lower values, are shown. In these photographs, the new Appleyard-van der Ziel system and the two new ultraviolet systems discovered by the author become stronger as the pressure lessens. The Lyman-Birge-Hopfield bands however, which are very strong at high pressures, become weaker and finally almost disappear at the lowest pressure at which a discharge is still possible. The first-negative bands of N_2^+, which are very strong in the tube at high pressures, also gradually become weaker as the pressure goes down. This is one reason for believing that the three band systems are emitted by the neutral nitrogen molecule. The fact that all three systems become stronger as the pressure is lowered indicates that they have similar origins. In fact, all three systems have the same lower electronic level, and two of the three systems originate on two levels of the set discovered in absorption by Hopfield and shown by him to fit a Rydberg series formula. Many other new bands are present on the spectrograms and some of them have been tentatively grouped together. A slide is shown in which the recent changes in our knowledge of the spectrum of the nitrogen molecule are summarized.

15. The Optical Properties of Magnesium Oxide. R. T. BRICE AND JOHN STRONG, *California Institute of Technology.*—The index of refraction of MgO has been measured for a number of wavelengths in the visible and ultraviolet, $N_C = 1.733$, $N_F = 1.747$. The dispersion is 55.3; the transmission limit in the ultraviolet is about 2200. The substance is found reasonably suitable for use with quartz and fluorite to form an achromatic triplet for the ultraviolet. Windows have been made of MgO for use in high-temperature furnaces and tested with lithium, sodium, potassium and calcium and found to withstand etching by these metals better than windows of other materials. MgO crystals may be obtained commercially up to about three centimeters square by one centimeter thick. It is possible that larger ones may be obtained if suitable care is taken to form them.

16. Fine Structure and Hyperfine Structure of Doubly Ionized Beryllium. S. S. BALLARD, O. E. ANDERSON AND H. E. WHITE, *University of California.*—The spectrum of doubly ionized beryllium is being investigated for the purpose of determining the fine structure as well as the hyperfine structure of the ^3P terms. The fine structure intervals in $1s2p$, ^3P as calculated theoretically by Heisenberg and others should not follow the Lande interval rule. With the small atomic number 4 and mass number 9 one would predict a nuclear spin of $I = \frac{1}{2}$ for the beryllium nucleus, and attribute it to a single unbalanced neutron. Since the magnetic moment of the neutron appears from other experiments to be quite small, relatively narrow hyperfine structure is to be expected even in the most favorable terms and spectrum lines of beryllium. The ionized spectrum has been excited by a direct current vacuum spark with 60,000 volts and a capacity of 0.3 mfd. The lines arising from the transition $1s2s$, $^3S_1 - 1s2p$, $^3P_{0,1,2}$ are observed at $\lambda 3720$. Two lines of the triplet, $^3S_1 - {}^3P_2$ and $^3S_1 - {}^3P_0$, are observed to fall practically together as predicted, and the hyperfine structure, although not resolved, is found to be quite narrow.

17. The Nuclear Magnetic Moment of Cobalt. KENNETH R. MORE, *University of California.*—A study of the hyperfine structure patterns in the Co I spectrum has led to a value of 7/2 for I (K. R. More, Phys. Rev. **46**, 470 (1934)). This study has been extended to include a determination

of the nuclear magnetic moment. The absolute hfs splittings of the $3d^74s4p\ {}^4D$ terms are found from the splittings of the lines of the $3d^84s\ {}^4P - 3d^74s4p\ {}^4D$ multiplet. The relative splittings of the ^4D levels are not in good agreement with those predicted by the Bacher-Goudsmit equations on the assumption that all the splitting is due to the coupling of the moment of the 4*s* electron with the nuclear moment. Better agreement is obtained by including the interaction of the orbital moment of the *d* electrons with the nuclear moment. With the assumption that part of the interaction is due to the 3*d* electrons, the coupling constant a' of the 4*s* electron is found to be 0.13 cm^{-1}. The nuclear *g*-factor is found, on the substitution of this value of a' in the equations given by Goudsmit (Phys. Rev. **43**, 636 (1933)), to be 0.77. This leads to a value of 2.7 nuclear magnetons for the nuclear magnetic moment of cobalt.

18. The Transfer of Translational and Vibrational Energy in Oxygen as Influenced by Small Impurities of Water or Ammonia Vapor. VERN O. KNUDSEN AND LEONARD OBERT, *University of California at Los Angeles.*—Previous experiments in this laboratory, based on reverberation measurements, have shown that at audible frequencies the absorption of sound in O_2 is greatly increased by the addition of small impurities of such gases as H_2O and NH_3. The present work, based on intensity measurements, extends these experiments to frequencies as high as 40,000 cycles. Kneser has shown that the results at audible frequencies are in good agreement with the recent theory of sound dispersion and absorption, provided the rate of adjustment of the vibrational energy of the O_2 molecule is strongly influenced by the presence of small amounts of other gases. Conversely, absorption measurements become useful for investigating energy transitions in molecular collisions. For example, it is found that the reaction rate k_{10} (number of transitions from the excited to the normal state per molecule per second) for O_2 is almost a linear function of the concentration of small impurities of NH_3, but is largely a quadratic function of the concentration of small impurities of H_2O. Although the results are in good agreement with Kneser's formula at frequencies below 10,000 cycles, the observed absorption at higher frequencies is in excess of the value given by this formula.

19. Experimental Features of the Spectrum of Samarium. ARTHUR S. KING, *Mount Wilson Observatory.*—The spectrum of samarium is of interest as material for term analysis, this element being near the middle of the rare-earth group, the end numbers of which have received most attention from analysts. In the present work, about 4500 lines from λ2900 to λ8700 have been given temperature classification. Over 400 of these fall in classes I and II, arising from low atomic levels. Many neutral lines not previously measured appear in the furnace spectrum. The lines of Sa II, which are of astrophysical interest, are selected by a comparison of furnace, arc and spark spectra. Since many of these singly-ionized lines appear in the furnace, the classification indicates their relative atomic levels in Sa II. The spark spectrum shows also some lines of Sa III in the region examined. Hyperfine structure appears in many samarium lines, especially those of Sa II, and is most frequent in the red and infrared. Those which are resolved are doublets, with the violet component stronger, and various degrees of separation up to 0.43 cm^{-1}. The nuclear mechanical moment indicated is therefore $(1/2)\cdot(h/2\pi)$; though an examination of samarium lines under high resolution is needed for the close patterns and to test for a possible influence of the known isotopes.

20. Spectrum of Aluminum Vapor Emitted by a Tungsten Coil in Vacuum. JOHN STRONG AND E. GAVIOLA, *California Institute of Technology.*—If a tungsten coil charged with aluminum is brought to incandescence in a vacuum of the order of 10^{-5} mm Hg, it evaporates a cloud of metal, which has been observed to emit a bluish-green light. The potential drop across the coil ranges from 10 to 40 volts. The emitted light has been photographed with a glass and with a quartz spectrograph and found to be mainly a line spectrum containing Al I, Al II and W lines. The following lines have been identified so far:

Al I		Al II		W	
3962	2373	3901	2631	4867	3376
3944	2372	3587	2369	4843	3077
3093	2367	3446	2321	4660	3024
3082	2269	3444		4365	
2660	2263	3057		4302	
2652	2258	3050		4295	
2575	2210	2816		4103	
2568	2204	2669		4074	
2378				4009	

The excitation seems to be produced by collisions with the electrons emitted by the incandescent filament and accelerated by the potential gradient between one end of it and the walls of the container. The intensity ratio of the lines is not the same as in the usual metal arc. Furthermore while the lines starting in the higher levels of Al are diffuse in the arc, they are notably sharp in the vacuum source. Displacements of some vacuum lines are indicated by the spectra. The presence of the W lines shows that part of the coil dissolves in the melting Al and is carried away while it evaporates.

21. The Spectrum of AsO. F. A. JENKINS AND L. A. STRAIT, *University of California.*—The band spectrum of AsO has been photographed in the second order of a 21-foot grating, by using as a source a high-frequency discharge through As_2O_3 vapor and helium in a sealed-off quartz tube. Two systems of double-double headed bands are observed, for which the *Q* heads are represented by the following equations:

$$\text{System } A: \quad \nu = \begin{cases} 31{,}655.8 \\ 30{,}631.1 \end{cases} + 683.8(v'+\tfrac{1}{2}) - 9.42(v'+\tfrac{1}{2})^2 - 966.6(v''+\tfrac{1}{2}) + 4.92(v''+\tfrac{1}{2})^2,$$

$$\text{System } B: \quad \nu = \begin{cases} 40{,}410.5 \\ 39{,}386.8 \end{cases} - 966.6(v''+\tfrac{1}{2}) + 4.92(v''+\tfrac{1}{2})^2.$$

The analysis of system *A* disagrees with that recently given by Shawhan and Morgan, and requires that the common final state be an electronic doublet, there being no doubling in the initial state of either system. An analogous situation exists for PO, in which the longer wavelength system (Geuter's *A*) shows a doubling of 226 cm^{-1}, agreeing with that of Geuter's *B* system, according to unpublished

work by one of us. The fact that we observe only the $v'=0$ progression in system B of AsO, and that the doublet components are very different in intensity, the high-frequency component being less intense, indicates predissociation in the upper state of this system. Bands with $v'>0$ have been observed under lower dispersion with other modes of excitation by de Watteville and by Shawhan and Morgan. Accepting the values $\omega_e'=1098$, $x_e'\omega_e'=6$ given by the latter authors, the electronic terms of the upper state become 39,862.0 and 38,838.3 cm^{-1}.

22. An f.l. Quartz Spectrograph. SINCLAIR SMITH, *Mount Wilson Solar Observatory.*—The novel feature of this spectrograph is a Schmidt camera consisting of a quartz correcting plate and four inch radius of curvature aluminized mirror. Having a two-inch aperture and a two-inch focal length the instrument is obviously very fast. An aluminized off-axis parabolic mirror is used for a collimator and the dispersion is produced by a Cornu quartz prism. Although the field is not flat, the instrument gives excellent definition from below λ3000 to about λ4500.

23. Intensities of X-Ray Reflection from Bi Crystals Between 25° and 530° Abs. R. B. JACOBS AND A. GOETZ, *California Institute of Technology.*—The integrated intensities of Mo $K\alpha$-radiation from (111) of highly purified Bi crystals have been measured between the boiling point of hydrogen and the melting point of Bi for the 2nd, 3rd and 5th order. It was found that: (1) Between 25° and 480° abs the integrated intensities follow the Debye-Waller function: $I/I_0=e^{-kT\sin^2\theta}$ with better precision than was found by previous authors on cubic crystals (NaCl, Al etc.) for higher temperatures and within smaller ranges of total energy variation, as far as $I/I_0=f(T)$ is concerned. This proves the validity of the above law in the T^3-region. (2) The comparison of the intensities among the different orders proves a good agreement for $I/I_0=f(\theta)$, although the original theory does not include the hemihedral hexagonal system to which Bi belongs. (3) For the last 40° before fusion a definite deviation from the law takes place, as $d(I/I_0)/dT$ (<0) begins to decrease and to reach even positive values, indicating a rearrangement in the sense of a larger degree of geometrical order within the crystal before fusion.

24. The Phenomenon of Supercooling. ALEXANDER GOETZ, *California Institute of Technology.*—The phenomenon of super-cooling in metals is interpreted as group-phenomenon (A. Goetz, Zeits. f. Kristall., Sonderheft 1934; Proc. Roy. Soc. Intern. Conference of Phys. 1934) as due to the fact that the transition into the rigid crystalline state has to be anteceded by a paracrystalline mesophase. It can thus be concluded that supercooling is the more likely the more the lattice of the crystal differs from a statistical (close packed) configuration and the more groups of paracrystalline qualities have been destroyed in the melt. Experiments prove that for metals with irregular lattices like Ga and Bi the supercooling can be induced over large ranges of temperature by superheating the melt or by surface forces acting upon sufficiently thin metallic layers. The beginning of the mesophase is determined for Bi and Ga to 10–12° above the melting point and the size of a group estimated to 10^{-4} cm.

25. A Precision Magnetic Field Standard. FRANK G. DUNNINGTON, *National Research Fellow, California Institute of Technology.*—The determination of e/m being made by a new deflection method (Phys. Rev. **43**, 404 (1933)) is limited in accuracy by the precision of the magnetic field. To reduce this uncertainty a very carefully built solenoid has been constructed. A heavy copper tube which is threaded on the outer surface has baked upon it a thin layer of bakelite for insulation. New threads are then cut in the bakelite (over those in the copper) leaving a continuous insulating layer about 0.004 inch thick. The copper wire wound in these threads was made especially for the purpose, commercial wire not being sufficiently round. The advantages of this design are: coefficients of expansion of wire and form are the same (not true with a marble form); the bakelite provides a firm machinable insulation which can not appreciably change the coil dimensions by moisture absorption; and the geometry is completely observable since bare wire is used. An accuracy of a few parts in 100,000 is attainable for a field of a few gauss. The method used in precisely comparing two magnetic fields will be described, including the precautions necessary in the potentiometer circuit and the establishment of the standard of voltage.

SATURDAY MORNING AT 9:00 O'CLOCK

26. A Null Method Photoelectric Photometer. HIRAM W. EDWARDS, *University of California at Los Angeles.*—Two photoelectric cells (RCA No. 868) are selected which have very nearly similar characteristics. The voltage on one cell is adjusted so that the anode currents through the two cells are identical when the cell surfaces are equally illuminated. A single galvanometer links the two electrical circuits with the two anode currents through it in opposition thereby producing a zero deflection when the intensities of the illumination are equal. The instrument shows a high degree of sensitivity with a good galvanometer, is inexpensive and is very easy to operate. In an application of this photometer to a measurement of relative intensities of two light sources, it is, of course, necessary to bear in mind the peculiarities of the cell response to the spectral distribution of energy in the sources.

27. Equations of State and Thermodynamic Functions for Substances with Variable Specific Heat. W. P. BOYNTON, *Oregon State College.*—In thermodynamical discussions it is often, though not necessarily, assumed that specific heat at constant volume is constant. From the

first and second laws of thermodynamics it can be shown that

$$C_v = T\int \frac{\partial^2 p}{\partial T^2} dv + f(T),$$

where $f(T)$ is a function of integration. This conclusion has been applied to a highly generalized equation, of which many well known equations of state are special cases, and expressions derived for the specific heat at constant volume, energy and entropy. Any equation of state may be expected to fit experimental data only over a limited field, and intrinsically discontinuous changes in state must necessitate a change in constants, if not in the form of the equation. The author discusses the possibility of bringing values of energy and entropy derived from such an equation into conformity with the third law.

28. Townsend Coefficients in Nitrogen. D. Q. Posin, *University of California. Introduced by Leonard B. Loeb.*—Carrying on the investigation of the Townsend coefficients for ionization by collision by electrons which had been completed for air by F. H. Sanders (Phys. Rev. **41**, 667 (1932); Phys. Rev. **44**, 1020 (1933)) in this laboratory, measurements have been extended to nitrogen. The purpose of this work is to determine these coefficients in a molecular gas, which does not react with the electrodes, in order to establish the values of these coefficients and their behavior, with the hope of detecting an influence on the value of the so-called positive ion coefficient β due to electrode material. In view of the fact that no data exist at present for nitrogen at low values of X/p, investigations were carried on in pure dry nitrogen using brass electrodes and the technique of Sanders with the results given in the table.

x/p	α	α/p	x/p	α	α/p
46	1.43	0.0143	34	0.714	0.00286
42	0.85	.0085	32	.50	.0020
40	.80	.008	28	.238	.000576
38	.77	.00513	26	.175	.00035
36	1.18	.00472	24	.0454	.000091

29. A Foucault Pendulum with Constant Amplitude. R. M. Langer, *California Institute of Technology.*—A Foucault pendulum of period 7.1 sec. and an amplitude of about 10 degrees is supplied with energy from an electromagnet during part of each upswing. The electromagnet devised by J. T. Barkelew is axially symmetrical and exerts a radial force on an armature attached to the pendulum suspension about 1 foot below the plane of the crossed knife edges on which the pendulum is supported. The force on the armature is zero at the center and increases gradually with displacement from the center. The amount of energy supplied to the pendulum can be varied by changing the time during which the electromagnet is activated as well as by varying the current. The impulses are timed by the pendulum itself. When it reaches the vertical the circuit is closed by a photoelectric device. At a fixed time later a photo-cell operates relays which open the circuit. It takes less than 20 watts to maintain constant amplitude of the pendulum although ten times as much could be furnished easily by this device. No appreciable change in motion of the bob results from the fairly weak and gradual impulses supplied in this way. The pendulum, designed largely by the late E. H. Kurth, is installed at the Griffith Observatory in Los Angeles.

30. Propagation of Micro-Radio Waves. Paul S. Epstein, *California Institute of Technology.*—As recent experiments by Marchese G. Marconi showed, micro-waves (of 50 cm wavelength) can be used for communication over distances several times larger than the range of rectilinear visibility. The question arises to what extent this is due to atmospheric influences. To answer this, the theory of propagation of such waves in the absence of any atmosphere was developed. Marchese Marconi's observations are not quantitative, qualitatively they are in agreement with the intensities calculated from formulas completely neglecting the influence of the atmosphere.

31. Relative Measurement of the Standing Wave System in a Mechanically Blown Flute Tube. R. W. Young and D. H. Loughridge, *University of Washington.*—Data are presented showing the air motion within a mechanically blown flute tube. The exploring probe consists of a short heated platinum filament welded between two long wire supports so mounted that the probe may be drawn to any position within the tube. The average resistance changes of the filament are determined by a Wheatstone bridge, and the periodic change by a suitably connected tune audio-frequency amplifier. Measurements show an enormous cooling near the mouth end, indicative of a turbulent motion which soon dies off as the distance from the mouth increases. Beyond this, sinusoidal standing wave systems are observed, terminating in a sort of exponential decrease in velocity amplitude beyond the open end of the tube.

SUPPLEMENTARY PROGRAM

1. A High Speed Oil Diffusion Pump. Hiram W. Edwards, *University of California at Los Angeles.*—The peculiarities of design in this pump are, the use of streamlines in regions of high pressure and the introduction of small angle conical surfaces for baffles in the regions of lower pressures. The conical baffles are particularly effective in preventing oil vapor from entering the chamber to be evacuated and at the same time in offering a minimum of impedance to the flow of gas through the pump. A three inch pump with this design and operating on a Western mineral oil especially prepared for it in this laboratory has shown a pumping speed in excess of 50 liters per second at a pressure of 1.0×10^{-4} mm.